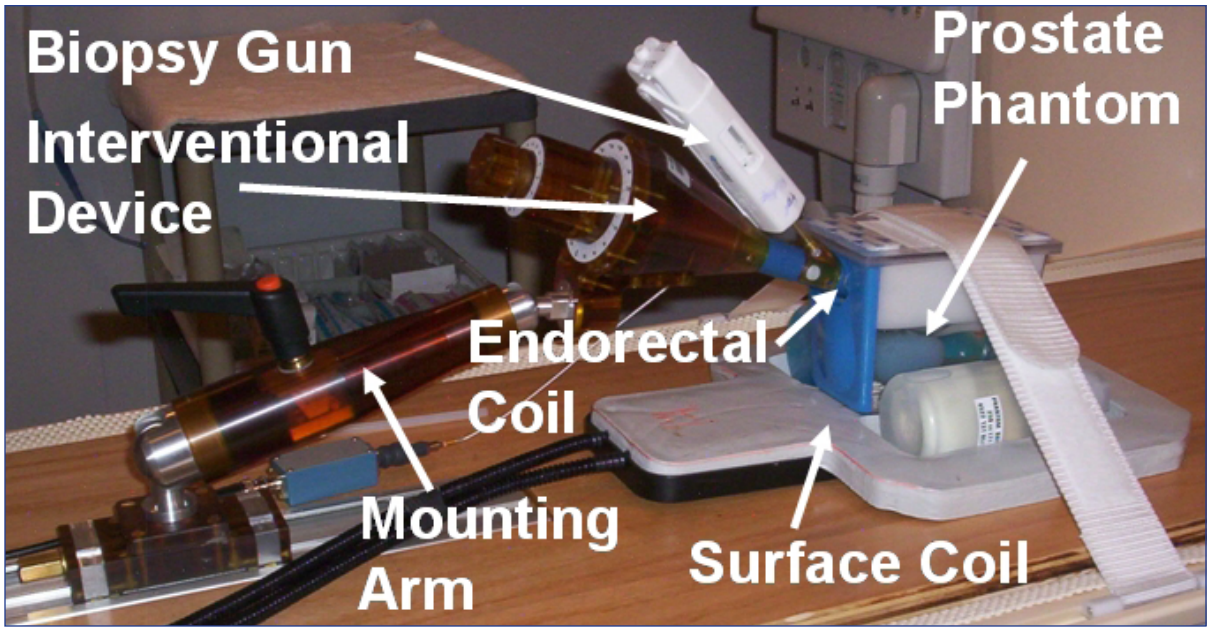

Fig. A9: MRI-guided transrectal imaging and biopsy device with integral endorectal imaging coil placed in a prostate phantom.

Researchers at the CISST ERC have developed a robotic device to place needles precisely into the prostate under Magnetic Resonance Imaging (MRI) guidance. The MRI provides an excellent soft-tissue contrast and has the potential to significantly improve image-guided prostate interventions, which are currently performed with ultrasound [1]. Transrectal MRI guided prostate interventions, such as biopsies and gold marker placements inside a high-field MR scanner, have been reported in initial clinical trials utilizing active [2] and passive fiducial tracking [3]. The CISST ERC recently completed initial phantom and clinical trials of a next-generation version of the system [2]. This new system, shown in Figure A9, employs innovative probe mechanics and a novel hybrid tracking method. The primary goals of the new system are to shorten procedure time and to significantly simplify deployment of the system on different scanners, without any compromise on previously achieved needle placement accuracy [2, 4, 5].

Figure A9 shows the new device placed in a standard prostate phantom. The device guides the needle tip of a standard automatic MR compatible biopsy gun to a predetermined target in the prostate. The device contains an endorectal probe with an integrated single loop imaging coil. A steerable needle channel is joined into the probe. The three degrees of freedom (DOF) to reach a target in the prostate are rotation of the probe, angulation change of the steerable needle channel, and insertion of the needle. The interventional device incorporates a hybrid tracking method comprised of passive fiducial marker tracking and joint encoders. At the beginning of the procedure, the position of the interventional device is obtained from MR images by segmenting the fiducial markers placed on the device.

Two clinical procedures have been performed on a 3T Philips Intera MRI scanner. One procedure encompassed combined biopsy and gold marker placements, while the second employed biopsy only. Figure 3 shows the results of the combined procedure. Four targets were selected on axial T2 weighted FSE images (Fig. A10, top row).

The targeting accuracy of three biopsy needle placements was assessed using proton weighted axial TSE needle confirmation images (Figure 4, second row). The mean in-plane targeting error for the biopsies was 1.1 mm with a maximum error of 1.8 mm.

These phantom studies and clinical procedures demonstrated accurate and fast needle targeting of the complete clinical target volume. The errors and procedure time compare favorably to the reported results achieved with our active tracking method

MRI-Guided Transrectal Prostate Intervention System

Axel Krieger, Peter Guion, Csaba Csoma, Iulian Iordachita, Anurag K. Singh, Aradhana Kaushal, Gabor Fichtinger, Louis L. Whitcomb

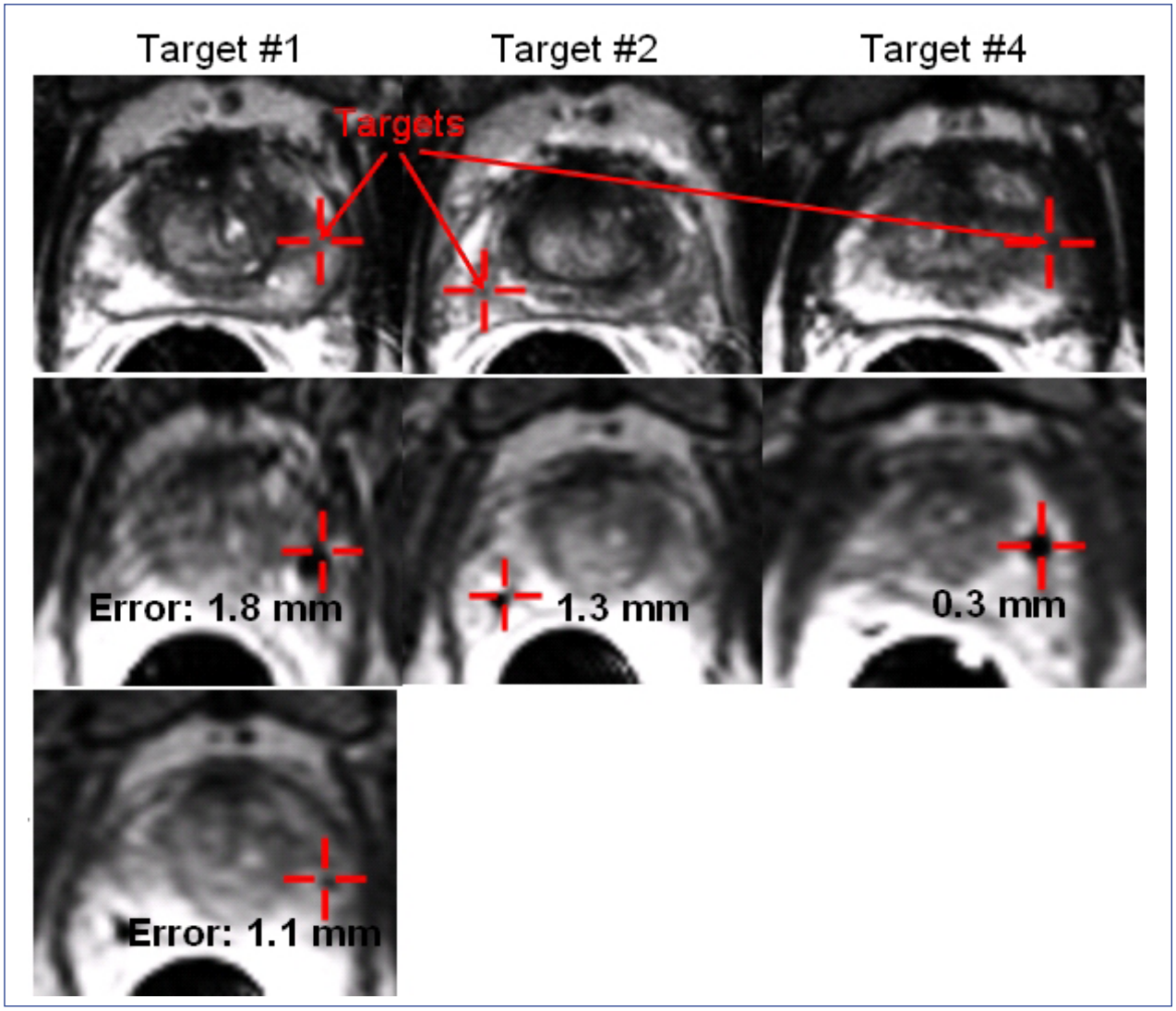

Fig. A10: Targeting images, needle visualization images, and gold marker image of clinical procedure using the transrectal prostate intervention system. Top image row: Suspicious targets (red cross hairs) were selected on axial TSE T2-weighted images. Second image row: The needle tip void was visualized in axial TSE proton density images. The desired targets match the actual position of the needle. Error number: The number indicates the in-plane targeting error for the needle placement. Third image row: Axial TSE proton density image showing the location of the marker placed at target location number 1. The marker void is visible close to the target.

in clinical trials (average error 1.8 mm and average procedure times of 76 minutes) [2, 4, 5]. The hybrid tracking method allows this system to be used on any MRI scanner without extensive systems integration and calibration.

JHU has applied for two patents of invention on this novel technology, and is successfully licensing these patents for commercialization.

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